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THE HUMAN ENVIRONMENT...

# Marine Pollution– Potential for Catastrophe

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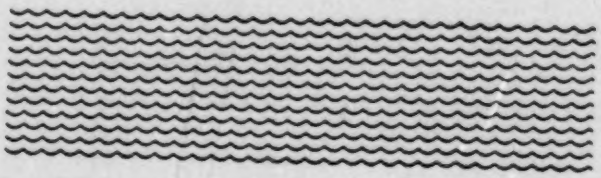

UNITED NATIONS

# rt on Marine Pollution Problems Remedies

**Schachter,**
ector of Research and Deputy Executive Director
he United Nations Institute
Training and Research (UNITAR) and

**l Serwer,**
istant Research Fellow of UNITAR

ollution is a global problem in several senses. It affects the health of
ns in all parts of the world; it affects all countries, both developed and
ng; and all countries contribute to some aspects of the problem. Some
ollution problems are local, but many have international implications.
rly if the effects of pollution on the living resources of the sea are con-
very few marine pollution problems can be considered matters of exclu-
cal interest.

not only a global problem in extent but a many-sided complex phe-
with interlocking economic, technological, political and legal aspects.
y, no single remedy or solution can be expected. The simple maxim
e who pollute should clean up or pay compensation has only limited
Vastes are disposed of in the oceans partly because the costs and risks
g them elsewhere are greater. In many cases, the blame for damage
e assigned. Even where it can be, liability may not be a deterrent. Out-
hibition may be necessary to prevent pollution but that may involve
al deprivation to legitimate users. It may well be that new structures of
are required, as the Secretary-General of the United Nations has rec-
ed, but the effective exercise of authority would still be limited by the
complexities of the problems themselves, by the gaps and uncertainties
fic knowledge and by the hard facts of economics and political interest.

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Clearly, the difficulties of setting goals and priorities will not be solved at a single stroke. Continuing wise management will be needed.

This management will need information as well as wisdom. We are profoundly ignorant of much that goes on in the marine environment. The oceans are, along with extra-terrestrial space and the interior of the atomic nucleus, one of the frontiers of scientific and technological research. The present ignorance is not limited to isolated details like the number of fish in the sea, though that too is a question which cannot now be answered satisfactorily. We lack knowledge of fundamental aspects of the physical, chemical and biological working of the oceans. It should be no wonder then that events in the sea like the recent explosion in the population of the Crown of Thorns starfish—a population explosion which has threatened to destroy coral reefs throughout the Pacific Ocean—are not quickly explained. This ignorance of the oceans and the life in them is one of the reasons why the problem of marine pollution and its effects must be treated with respect and caution.

The need for information about pollution has been recognized in the plans for world-wide monitoring of the oceans—most notably, the Integrated Global Ocean Station System. That plan rests on an impressive technical capability to gather data through automated buoys and transmit the information throughout the world. But technical monitoring capability is not in itself sufficient for producing useful knowledge—it needs to be designed and employed for scientific understanding. Yet because of our ignorance of the oceans, we may not have reached the point where our scientific knowledge of ocean problems would justify a data-gathering system on a global scale. Whether or not this is the case, it is quite clear that routine global monitoring will not in itself provide the information required for pollution control. Ocean research, and especially experimentation, are equally required and beyond that a much greater theoretical understanding of the ocean systems and how they work. Moreover, for adequate fact-finding a variety of investigators will still be needed, even though there may be several thousand automated buoys dispersed in the oceans. We may recall that the harmful effects of DDT were discovered by the efforts of a number of bird watchers, game wardens, conservationists and a variety of professional scientists. It is unlikely that a single global automated monitoring system can take the place of that kind of information-gathering network.

What measures can and should be taken in marine pollution control is complicated by the variety of pollutants. These vary not only in their chemical composition and behaviour, but also in the manner in which they enter the marine environment and the nature and extent of their effects. Some materials which pollute the marine environment are discharged intentionally; others are only discharged accidentally. Some sources of marine pollution can be pinpointed; others are for all practical purposes untraceable. Some marine pollutants maintain their chemical integrity for decades and even centuries; others are degraded to harmless materials in a matter of hours or days. Some marine pollutants present a clear and immediate threat to marine life; others may only be dangerous in the long term, and the precise nature of these dangers may still be unknown. No single measure or type of measure, on either the national or

international level, is adequate to meet the range of marine pollution problems. Marine pollution control measures must be tailored carefully to fit particular problems. Moreover, the fashioning of these measures is not a task for the imagination alone. The present international system, based as it is on the interdependency of sovereign States, is the material from which solutions must be cut. This system has both considerable capacity and various limitations for dealing with marine pollution problems.

The capacities can be illustrated most clearly if the specifics of marine pollution problems are immediately at hand. Accordingly, in what follows we select what appear to be the most important marine pollution problems and summarize what is known about where the pollutants originate, the extent to which they are found in the marine environment, how they affect the marine environment, what international controls now apply and the prospects for future pollution and its control. This is done under four headings: oil, chlorinated hydrocarbons, wastes discharged from coasts and wastes dumped from vessels. This discussion of specific marine pollution problems and remedies is prefaced by a few background facts about the marine environment which bear on the problem of marine pollution.

## Some Basic Facts about the Marine Environment

While the primary chemical constituent of the oceans is water, many other chemicals are found dissolved in this water. Even in "natural" sea water, these chemicals include many of the substances which we refer to as pollutants. Mercury, lead, hydrocarbons similar to those found in oil, and some radioactive nuclides would all have been found in the oceans millions of years ago. The difference between now and millions of years ago is that man is adding to the concentrations of these materials, as well as introducing new materials like chlorinated hydrocarbons, in amounts which are significantly altering the chemical composition of the marine environment. In a number of cases, the "significant amounts" added by man's activities are doubling the natural concentration of marine chemicals and introducing new chemicals in concentrations approaching those of naturally occurring chemicals.

The significance of these added chemicals in the marine environment lies in their effects on the ecology of the marine environment, that is in their effects on the relationship among living things and between living things and their environment. These relationships are delicately balanced. Marine life is interconnected in a web of interrelated food chains, all of which depend in the end on the chemical situation in the marine environment. Diversity of species is an essential characteristic of these food webs, for diversity is frequently associated with stability in ecological systems. At the base of marine food webs there is usually some form of phytoplankton, tiny plants which float on the surface of the sea. Phytoplankton are responsible for the primary production of 90 per cent of the living material in the sea. Moreover, they have produced by photosynthesis about 70 per cent of the oxygen on the earth. The marine life which supplies man with food, usually fish 10 inches or longer, is found relatively high

in the marine food webs. The continued production of these fish depends on the maintenance of the species below them. Of course, changes in food webs have always occurred, with some species becoming extinct and others evolving. The adaptive capacity of marine life may not, however, be unlimited, and the adaptations are not necessarily beneficial to man. The greatest long-term danger from marine pollution lies in its potential for upsetting the ecological balance of the oceans in such a way that man will find the usefulness of the marine environment vastly diminished. That this can in fact happen is clearly demonstrated in many of the world's freshwater areas.

The ecological balance of the oceans can be upset in many ways. Some pollutants simply poison the animals and plants with which they come into contact. Other pollutants make such a demand on the oxygen dissolved in sea water—oxygen which is essential to the life of marine animals—that the living competitors suffocate. Some pollutants encourage the growth of a single species which either consumes or poisons other species. Still other pollutants accumulate in marine food chains and webs because they are not readily metabolized. Pollutants concentrated by food chains can reach levels which upset physiological functions. Examples of these mechanisms can be found in the outlines of the effects of specific pollutants given later in this article.

The operation of these mechanisms and the effects they have are determined, in part, by where in the marine environment pollution occurs. The oceans are not homogeneous. Physical parameters like temperature and pressure vary greatly. Marine life and the nutrients required to support it are not evenly distributed over the oceans, but are instead found concentrated in certain areas. These fertile areas of the oceans often lie along coastlines; estuaries are the most fertile areas. Some species of marine life are found concentrated in certain areas, while others range over wide expanses of the oceans. Even the motion of water in the oceans is not uniform. As much as waves may appear to be similar all over the earth, oceanographers find that some water moves rapidly in ocean currents and some water remains in much the same place for many years. Putting a pollutant in some ocean areas is like putting it in a lagoon: it stagnates for a long time. On the other hand, pollutants do not have to be put in a particular part of the oceans, or even in the oceans at all, in order to end up there. Not only do the rivers run into the sea and the currents of the sea run over the earth, but the atmosphere and the sea constantly exchange materials.

## Oil

Hydrocarbons in the marine environment come from a variety of sources. These include natural submarine seepage, natural decay of marine plant and animal life, shore-based industrial and transport activities, off-shore drilling, wrecked oil tankers and other ships, and discharges from ships which pump out cargo and ballast tanks with sea water. Of the two natural sources, submarine seeps may be controllable, but plant and animal decay is not. Most of the hydrocarbon due to human activities is crude oil, but fuel oil has also been spilled. Fuel oil is usually much more toxic than crude oil.

Of the persistent pollutants in the marine environment, oil is found in the greatest quantities. A recent estimate puts oil pollution from oil transport activities alone at one million metric tons per year and the total from all human activities at no less than 10 times this amount. Another recent estimate puts the volume of oil discharged from sea-going sources, including off-shore wells, at 1.5 million tons per year and the volume of oil from land-based sources at no less than 3 million tons per year. If these estimates are correct, the total amount of oil entering the marine environment from human activities is approximately as great as the total amount of hydrocarbon entering the marine environment from natural plant and animal decay. These losses of oil from human activities are not uniformly distributed in the world's oceans. A large fraction of the total oil pollution originates from shore installations and off-shore wells. Much of the oil pollution from ships is spilled in coastal areas, particularly in harbours. The major sea lanes for all transport at present—the Persian Gulf, the Mediterranean, the western coastal waters of Europe and the eastern coastal waters of the United States—all lie close to coastal areas.

Due to the research efforts of recent years, an outline of what happens to crude oil once it enters the marine environment is now clear. The oil first forms slicks whose composition varies from virtually pure oil to a water-in-oil emulsion to an oil-in-water emulsion. Some lighter fractions of oil, including the toxic aromatic hydrocarbons, evaporate quickly if they are exposed to the atmosphere. The slicks float on the ocean surface, spreading and travelling in a way determined primarily by winds and ocean currents. If the oil becomes adsorbed on solid particles—which happens more often in coastal areas—it may sink. Little is known about how far the oil sinks and what happens to it deep below the surface or on the bottom. Oil on the surface undergoes auto-oxidation, a process catalyzed by the mineral salts in sea water and by sunlight, and bacterial oxidation. Bacterial oxidation is favoured by dilution of the oil in water and by heat. Below 10 degrees centigrade, bacterial oxidation is very slow, and oil spilled in arctic areas may last as long as 50 years. Even in temperate zones in the summer, as much as 50 per cent of the oil may remain unoxidized after a week. In coastal areas, oil may be beached, and oxidation continues on the beach. If the oil remains on the sea, tarry lumps are formed. Tarry lumps have been found in the Mediterranean consisting of oil which had been at sea for as long as two months. On a cruise of a Woods Hole research vessel between Rhodes and the Azores, these tarry lumps were found in at least 75 per cent of the tows made with neuston nets on the surface of the sea. In the Sargasso Sea, a region of the North Atlantic known for its masses of floating vegetation which is not crossed by major shipping lanes, a research vessel found as much as three times as much tarry material as Sargasso weed in its neuston nets. The Expedition "RA" has reported to the Inter-Governmental Maritime Consultative Organization (IMCO) that it sailed through water "visibly polluted" with "tar-like or asphalt-like material" on six out of 52 days of its trans-Atlantic voyage.

In the short term, oil can cause damage to both marine life and the recreational potential of coastal areas. Damage to marine life varies greatly with the species involved, the type of oil and the length of exposure. Birds are particu-

larly sensitive to oil pollution, and attempts to save them by cleaning have been largely unsuccessful. Fish populations do not appear to be affected by short-term exposures to crude oil spills, although fish taken from water polluted with crude oil may be unpalatable. Fuel oil, on the other hand, can kill fish in great numbers. Recovery of a coastal area from the effects of a fuel oil spill can be very slow. Chronic oil pollution, a condition present in some ports, appears to have more drastic effects on marine life than isolated oil spills, primarily due to deoxygenation of the water. Damage to beaches from oil spills appears to be temporary, but it may not be limited to the inter-tidal zone. Without special efforts to remove the oil, oil on beaches can last for months, that is for long enough to have a serious effect on areas which depend on beaches for their livelihood.

The long-term, low-level effects of oil pollution are still not well understood. These effects are probably non-lethal to marine life, though some chemicals present in crude oil may be carcinogens. The non-lethal long-term effects may, however, pose serious problems. Even if hydrocarbons present in oil do not kill marine life, they may accumulate in food chains and affect human beings who eat fish. There have been complaints in several countries about fish which taste like crude oil. It has been suggested that hydrocarbons present in crude oil may interfere with biological processes which depend on low concentrations of chemical messengers—many of which are hydrocarbons—in sea water. The oxidation of oil by bacteria, though it may provide an increase in nutrients available to the food web, depletes the dissolved oxygen supply on which much marine life depends. Under average conditions, the complete oxidation of one litre of oil would deplete 400,000 litres of sea water of its dissolved oxygen. The long-term effects of oil which has sunk to the ocean floor, where the supply of dissolved oxygen is very limited, are still unknown.

Many techniques have been tried for reducing the volume and effects of oil pollution. The most effective techniques have, so far, been straightforward, arduous and expensive. They involve, in general, mechanical removal of oil from polluted beaches, from the surface of the sea or from wrecked tankers. Mechanical removal of oil from beaches is labour-intensive and messy, but with enough effort significant amounts of oil can be removed. Skimming oil from the surface of the sea in large quantities is becoming feasible. The Soviet Union reports that it now has available a specially equipped ship which can skim seven tons of oil per hour from the surface. It is possible to prevent damage from oil by removing it from tankers before it spills. The United States is experimenting with a system of rubber bladders capable of removing large quantities of oil from wrecked tankers. Canada has succeeded in pumping a large quantity of oil from a sunken tanker. Bombing wrecks in order to burn the oil and sinking oil with sand or hydrophilic chemicals have reduced the volume of oil which reaches beaches, but the effect of these measures on marine life is still largely unknown. Oil slicks have been contained with booms, but weather conditions can make this procedure difficult. Chemical dispersants have been sprayed on oil both on the sea and after it has been beached, but the discovery that the dispersants are sometimes more toxic to marine life than the oil they

disperse has shed doubt on the wisdom of using dispersants extensively. In addition, oil which is dispersed may still be dangerous to marine life.

In the future, oil pollution of the marine environment can be expected to increase unless steps are taken to cope with both the increasing volume of oil being produced and transported and the increasing risks of production and transportation. Total world production of oil is expected to increase five times by 1980. The percentage of this production coming from offshore wells is expected to increase as well. Wells are continually being drilled in deeper water, with increasing risks of an accident and increasing difficulties in plugging a blow-out. Many wells are being drilled off the coasts of countries which must import help from abroad when a blow-out occurs. The size of oil tankers used for the transportation of oil is increasing. While many of the new tankers are equipped to retain oily water used for cleaning out tanks on board, the damage which could result from a wreck of one of these tankers is greater than the damage from the *Torrey Canyon*. The discovery of oil in Alaska and the plans to transport it to the United States through the Northwest Passage have raised the possibility of a major oil spill in the Arctic.

A number of legal measures have been taken to deal with the growing threat of oil pollution, and particularly oil pollution from ships, on both the national and international levels. They have been aimed at four objectives: (i) limiting or prohibiting the intentional discharge of oil, (ii) preventing accidents which may cause oil pollution, (iii) eliminating or mitigating oil pollution arising from an accident, and (iv) imposing liability for damage caused by oil pollution. Besides these specific steps, both the 1958 Convention on the Continental Shelf and the 1958 Convention on the High Seas oblige States to take measures for the prevention of damage due to oil in the marine environment.

The limitation or prohibition of the intentional discharge of oil is the object of the 1954 Convention for the Prevention of Pollution of the Sea by Oil, as amended in 1969. This Convention prohibits the discharge of oil by ships except under specified conditions and requires special fittings to prevent the escape of oil. It also requires detailed records to be kept and provides for rights of inspection. In the future, any strengthening of this Convention is likely to hinge primarily on the provisions for supervision of compliance rather than on the substance of the prohibition.

For the prevention of accidents, the importance of which has been illustrated repeatedly by incidents off many coasts, there is a need for legal requirements concerning the design and equipment of ships, the use of navigation instruments, qualifications of officers and crews and in some cases maximum speeds, traffic lanes and compulsory pilotage. Regulations of this kind have been adopted in many national jurisdictions but they have not yet been prescribed by international Conventions. The Inter-Governmental Maritime Consultative Organization is planning to hold a conference in 1973 for the preparation of a "suitable international agreement for placing restraints on the contamination of the sea, land and air by ships, vessels or other equipment operating in the marine environment". Even apart from international agreements, however, States presumably have the right under general international law to

prohibit any ship which does not conform to reasonable standards of design and equipment (or which fails to meet other safety requirements) "from crossing their territorial seas and contiguous zones and from reaching their ports". The exercise of this right by even a small number of States could have a widespread effect, for many oil tankers depend for their trade on a limited number of major ports.

The elimination or mitigation of oil pollution arising from an accident which has already occurred is the object of the 1969 Brussels Convention relating to Intervention on the High Seas in Cases of Oil Pollution Casualties. This so-called Public Law Convention contains provisions entitling a coastal State facing grave and imminent danger from oil pollution to take necessary measures to prevent damage to its coasts. Although coastal States may be said to have this right already, independently of the Treaty, the new Convention is a step forward in that it spells out the modalities for the exercise of that right and provides for consultation with States and persons who might be affected. It also includes specific provisions for conciliation and arbitration in the event of controversy between States Parties to the Convention.

The imposition of liability for damage caused by oil pollution is the object of the 1969 Convention on Civil Liability for Oil Pollution Damage. While providing for strict liability irrespective of fault, the Convention entitles an owner who is not actually at fault to limit that liability to an aggregate sum of 210 million francs (approximately $14,000,000). The Convention also requires owners to maintain insurance or other financial security, a requirement which may result in improvements in ship design and equipment as a consequence of conditions that are likely to be required for insurance.

These measures for the control of oil pollution from vessels are important, but they would be more effective if the capability of States to take action were increased. The burden of responsibility for acting to prevent oil pollution rests with States, but not all States are equipped to execute this responsibility. Capping blow-outs, detecting oil spills and identifying their origin, bombing a wrecked tanker in order to set its oil on fire, sinking an oil slick, skimming oil from the surface of the sea and any number of other measures which can, and which under existing and proposed treaties should, be taken by coastal States are all measures which require a considerable degree of technical expertise and extensive financial resources. This is true as well for many of the measures which States can and should require of the vessels operating under their own flags. Few States possess all the expertise they need or could use in this area. It might, indeed, be wasteful if all States did individually possess the capacity to take all possible measures for the control of oil pollution from ships and off-share wells. Even wealthy countries may find it difficult to mobilize the necessary manpower, technology and hardware. Individual developing countries, many of which have only short coastlines, may find it much more difficult to institute the necessary pollution control measures. There would appear to be considerable potential for international action in helping States to acquire, either singly or co-operatively, the capability of carrying out adequate oil pollution control.

Even with adequate control of oil pollution from ships, however, the problem of oil pollution would not be solved. Shore-based sources of oil pollution account for at least as much oil pollution as the sea-going sources. The point is being reached at which the returns on efforts to control shore-based sources of pollution may be greater than the returns on efforts to control pollution from ships. Some individual States have taken steps to curb shore-based sources of oil, but there has been no co-ordinated effort to reduce oil pollution from shore-based sources. In this as in other pollution problems, a State which is conscientious in controlling pollution may be putting its industry at a competitive disadvantage to the industries of States which do not take steps to control pollution. The provision of article 25 of the 1958 Convention on the High Seas that "All States shall co-operate with the competent international organizations in taking measures for the prevention of pollution of the seas or air space above, resulting from any activities with radio-active materials or other harmful agents" creates an obligation which could apply to shore-based sources of oil, but this depends on international organizations doing their part in initiating the necessary measures. Any such effort would have to recognize that, as in the case of oil pollution from ships, the control of oil pollution from shore-based sources requires a considerable degree of expertise. There are many different technological, administrative and legal tools available for controlling industrial pollution. Sharing experiences with these tools, as well as co-ordinating the use of them when it is desirable, can help to make them both more effective and more equitable.

**Chlorinated Hydrocarbons**

The term chlorinated hydrocarbons refers to a group of pollutants which are chemically similar but come from different types of human activity. The chlorinated hydrocarbon pesticides—including DDT, dieldrin and endrin—and the polychlorinated biphenyls (PCBS) are known to be important pollutants in the marine environment. The pesticides usually enter the environment as sprays for agricultural pest control. PCBS are not intentionally introduced into the environment on a large scale. They are manufactured for a variety of uses, including insulation and fire retardation. How they enter the marine environment is still unknown. Although chlorinated hydrocarbons—and particularly DDT—are used in many parts of the world, much of their production is concentrated in the developed countries. In 1968 approximately 25 per cent of the total world production of DDT was manufactured in the United States. Two thirds of this DDT was exported.

Chlorinated pesticides enter the marine environment in two ways: in water run-off from agricultural areas and from the atmosphere. The major source of the pesticides in the marine environment is the atmosphere. Greater concentrations of pesticides are not necessarily found in areas where the amount of run-off from agricultural areas is greatest. Rather, the global distribution of pesticides appears to be what would be expected if the pesticides were distributed by winds. As much as 50 per cent of the pesticides sprayed in agricultural areas never

reaches the plants they are intended to protect. Much of the remaining 50 per cent is carried off by winds into the atmosphere. DDT has been detected on dust particles in areas far from any spraying of pesticides. Precipitation carries pesticides from the atmosphere into the marine environment. DDT and DDT residues have been found in penguins in the Antarctic and in petrels in Bermuda.

Precisely how much chlorinated hydrocarbon is in the marine environment is not known. One estimate puts the total amount of DDT—the chlorinated hydrocarbon which has been manufactured in the greatest quantities—in the biosphere at one billion pounds. Since DDT is a persistent pollutant—its half-life is probably between 10 and 50 years—much of the total amount can be expected to enter the oceans. The total amount of DDT in the marine environment is not, however, an enlightening fact. In terms of the effects of chlorinated hydrocarbons on marine ecology, what counts is the concentrations found in marine life. Concentrations of chlorinated hydrocarbons vary greatly according to where one looks for them. Chlorinated pesticide concentrations large enough to cause widespread concern are found in fish and marine birds. PCB concentrations are usually several orders of magnitude smaller. Chlorinated hydrocarbons are not readily metabolized, but dissolve in fat. Even when they are metabolized the products of the metabolic reactions are usually chlorinated hydrocarbons themselves. Because they are not readily metabolized, chlorinated hydrocarbons accumulate in marine life and are concentrated by food webs. Oysters alone have been found to amplify small concentrations of DDT 70,000 times in a month.

At their present levels in the marine environment, chlorinated hydrocarbons do not appear to be directly lethal to any species. Serious non-lethal effects are, however, possible. Laboratory experiments have shown that low concentrations of DDT can inhibit photosynthesis in phytoplankton. It has been shown that this effect does not threaten the world's oxygen supplies, but because phytoplankton are at the base of many marine food chains, changes in the rate of primary photosynthesis are certainly critical to man's food resources. Field observations and laboratory experiments have shown that DDT is causing reproductive failures in a number of marine and other birds and possibly in crabs as well. The reproductive failures in birds are often due to thin-shelled eggs, which in turn are due to interference by DDT in the normal sex-hormone metabolism. DDT and other chlorinated hydrocarbons are present in detectable amounts in other forms of marine life, including marine fish. Levels of DDT contamination in marine fish may, in fact, be approaching levels associated with the collapse of fisheries in freshwater areas. In which case, according to one expert, we could soon expect a repeat performance in the oceans. Much less is known about the effects of PCBS than about the effects of DDT.

The control of pollution by chlorinated hydrocarbons depends almost entirely on discontinuing their use. Methods of control which apply to many other pollutants—such as degradation, dispersion and collection—are not feasible for persistent pollutants found in low concentrations. Chlorinated hydrocarbons are not readily degraded to harmless materials; they are already dispersed and cannot be collected. The major problems facing control of chlorinated hydrocarbons are to determine what levels are harmful and how their use can be

discontinued before concentrations reach these levels. The first is a technical problem with a technical solution. The second is an economic, social, administrative, legal and even a political problem and its solution is likely to be complex. Particularly in the case of the pesticides, prohibition is likely to be expensive and difficult in every way. The chlorinated pesticides are considered essential to maintaining health in countries with insect-borne disease. Several countries, including Hungary, Sweden and Denmark, have prohibited the use of DDT, but none of these has a major problem with insect-borne disease. Even in these countries, the banning of DDT may not be an unalloyed benefit. As the recent deaths from parathion, an insecticide which has been used instead of DDT in the United States, remind us there is as yet no entirely satisfactory substitute for DDT. Banning DDT and other chlorinated hydrocarbons in individual countries may not have the desired effect, for this may lead to the economic dumping of large quantities in tropical countries where there are pests enough and little control over the production and use of pesticides. The Director-General of the World Health Organization has made it clear that he feels DDT should not be banned world-wide because of its importance in malaria control.

In the future, chlorinated hydrocarbons in the marine environment are likely to increase. With the production of many chlorinated hydrocarbons continuing to increase, a major spill of these materials becomes more likely. The example of the Rhine fish kill, in which approximately 200 pounds of the pesticide endosulfan killed at least 100 tons of fish, is now a matter of record. Even without such a spill, and even if the use of chlorinated hydrocarbons were discontinued today, one might expect an increase in their concentration in the marine environment due to those already en route to the oceans. Several species of marine birds have already been decimated by reproductive failures due to chlorinated hydrocarbons, and extinction of some of these species appears likely. The loss of several bird species may not seem to outweigh the health benefits of chlorinated pesticides, but the long-term effect of these losses on marine ecology is not yet known. Nor, for that matter, is there any reason to believe that chlorinated hydrocarbons will affect only bird populations. No final accounting can be made until all the costs are reported. Action for the control of chlorinated hydrocarbons should not, however, have to wait for a final accounting. A number of recent suggestions for general principles governing man's interaction with his environment have recognized the importance of preventing irreversible ecological changes and preserving the diversity of natural systems. It is possible that the Universal Declaration on the Human Environment to be presented at the United Nations Conference on the Human Environment in Stockholm next year will incorporate such suggestions. While a final accounting on DDT and other chlorinated hydrocarbons is not yet available, the extinction of bird species due to the effects of DDT and other chlorinated hydrocarbons is an irreversible change.

As already mentioned, article 25 of the Convention on the High Seas requires States Parties to co-operate with the competent international organizations in taking measures for the prevention of pollution of the seas resulting from any activities with "harmful agents". Since DDT, and perhaps other chlori-

nated hydrocarbons as well, may be considered a "harmful agent", the States Parties would be obliged to co-operate with the competent international agency in limiting DDT, but thus far no international organization has adopted recommendations restricting the use of DDT or other chlorinated hydrocarbons. Some States have prohibited the use of DDT, but without international action unco-ordinated national measures may do no more than change the pattern of use of chlorinated hydrocarbons. Other countries have banned the production of DDT, at least for some purposes. While banning production may be the most effective way of halting DDT use, it may put an excessive financial strain on developing countries who must then purchase higher-priced substitutes. International measures are needed to co-ordinate a planned reduction in the use of chlorinated hydrocarbons. Such measures might include regulating trade in chlorinated hydrocarbons, setting standards for their use and providing subsidies to developing countries for the difference in price between DDT and less persistent substitutes. Some uses, such as the spraying of crops, might be identified as non-essential and subject to limitation. Other uses, such as the painting of walls with DDT to prevent the spread of malaria, might be considered essential and exempt from limitations. Regulating trade and providing subsidies may be facilitated by the concentration of chlorinated hydrocarbon production in developed countries.

In addition, the international community should consider equipping itself to gather the knowledge it needs to take action on questions of this type. At present, the long-term, low-level effects of pollutants in the marine environment are primarily matters for scholarly study and lay speculation. The problem of how technical matters for widespread concern are to be presented reliably for national and international consideration and action remains unsolved, particularly on the international level. Technical problems are, of course, handled by the secretariats of international organizations, committees of scientists and the normal diplomatic apparatus. There is, however, little machinery for direct interaction between those with technical knowledge and those with administrative and legal skills.

### Wastes Discharged from Coasts

The term wastes is a broad one covering materials of different chemical compositions from many different sources. Wastes are often divided into two major categories: domestic and industrial wastes. For our purposes, domestic wastes include domestic sewage, wastes from food-processing, detergents, and run-off from agricultural areas. Industrial wastes include heavy metals, radioactive nuclides, inorganic chemicals and heated water. Wastes discharged from coasts enter the marine environment from rivers used for waste disposal, as well as from effluent points located on the coast. The composition of wastes entering the marine environment varies greatly according to the source of the waste and the extent of treatment it receives. Pollution from wastes differs from chlorinated hydrocarbon pollution, and in part from oil pollution as well. in so far as the bulk of the pollution from wastes arises from the intentional discharge of ma-

terials into the marine environment. Marine pollution from wastes is generally a less severe problem than fresh water pollution from wastes, but the two issues are not independent of each other. For example, it has been noted that indiscriminate discharges have converted many of the rivers of northern England into biological deserts and that as a result, the seas into which they flow are in danger of falling into the same state. Estuarine disposal of wastes can be particularly harmful because as much as two thirds of the marine animal population depends directly or indirectly on estuarine waters.

The problem of wastes in the marine environment is widespread. In a United Nations survey of Member countries in 1966, 43 of the 49 countries reporting marine pollution problems cited pollution from wastes as a problem. The single most frequently cited marine pollution problem was domestic wastes. The 32 countries citing domestic wastes as a problem included both developed and developing countries. Indeed, the problem of domestic wastes depends in large part on population and its distribution, perhaps to a greater extent than any other form of pollution. Agricultural practices also affect the quantity of domestic wastes, with fertilizers and animal wastes making a significant contribution. In the United States, the volume of animal waste has been estimated to be 10 times as great as the volume of human waste.

Some type of industrial waste was cited as a pollution problem by 38 of the 49 countries reporting marine pollution problems in the United Nations survey. The most frequently mentioned industrial wastes were heavy metal compounds, petrochemicals, pulp and paper wastes, oil, and dredging and mining spoils. Although some marine pollution from industrial wastes is accidental and occasional, most is intentional and routine. Industries are often located along rivers, lakes and coasts because of the ease of waste disposal in water. As is the case for domestic wastes, the methods used for disposing of industrial wastes vary from mere dumping of untreated materials to the discharge of extensively treated effluent, but it is often the case that industrial wastes are more toxic than domestic wastes.

The effects of both domestic and industrial wastes depend on the chemical composition of the wastes, their physical state, the method of discharge, the place of discharge, and local environmental conditions. Two of the more important polluting effects of a number of domestic and industrial wastes in the marine environment are over-fertilization and poisoning. Over-fertilization is due to an excessive flow of nutrients into the marine environment. The nutrients can be many different chemicals including the nitrates found in fertilizers and the phosphates found in detergents. Over-fertilization becomes evident when the population of a marine species, often a species of phytoplankton, increases very quickly, causing what is known as a bloom. Blooms occur naturally—that is without the addition of nutrients into the marine environment by man—but they have become much more frequent with the increased disposal of nutrients by man. Blooms of phytoplankton known as the red tide occurred along the Florida Gulf Coast in 1916, not again until 1932, not again until 1948, and then in 1952, 1953, 1954, and every year between 1957 and 1964 inclusive. Other species of phytoplankton have caused different coloured tides off the

coasts of Ceylon, Brazil and Spain. Irritating smells are often associated with blooms, and some blooms kill other forms of marine life. When a bloom dies, decay of the organic material can cause de-oxygenation of the water. Serious economic damage to coastal recreational areas and to fishing have resulted from outbreaks of red, and other, tides.

Blooms of phytoplankton are not the only way in which over-fertilization from domestic and industrial wastes can affect the marine environment. The chemical breakdown of nutrients uses oxygen dissolved in sea water. Since this oxygen is essential to marine life, shortages due to the chemical breakdown of nutrients can decrease the fertility of ocean areas. There are indications that such shortages are occurring in the Baltic Sea due in part to phosphorous from human activities. The situation there may be such that an increase of organic material probably will result in permanent anaerobic conditions. In many coastal areas, nutrients have encouraged the growth of bacteria to the point where the waters are unsuitable for bathing. Despite extensive treatment of domestic sewage, the bacterial count in New York Harbor has increased at least 10 times between 1948 and 1968, probably due to nitrogen enrichment from land run-off. The invasion and decimation of commercially utilized kelp forests off the California coast by sea urchins was traced to sewage effluent. Sewage effluent probably encouraged the growth of both the kelp and the sea urchins, but the balance tipped in favour of the sea urchins.

The danger of poisoning from domestic and industrial wastes depends in part on the ability of individual species and food webs in the marine environment to concentrate poisonous materials. Although the water from red tides off the Florida coast seems not to be poisonous to human beings, oysters taken from the same water and eaten can cause illness. Mercury which was discharged in small quantities from a factory in Minamata, Japan, was diluted in a bay but accumulated in fish. Throughout the 1950s and into the 1960s, incidents of mercury poisoning from these fish occurred. If what is known of the pollution of freshwater areas is an indication of what may be happening in the oceans without our knowledge, pollution of the oceans by other poisonous metals may well be discovered soon. Strontium 90, most of which comes from atmospheric nuclear weapons tests conducted over the last 25 years, may have accumulated in some fish to levels which contribute to high mortality rates. Although many scientists feel there is no danger from radioactive wastes in the marine environment, at least one expert feels that the danger from accumulated radioactive wastes is so great that no more marine disposal of such wastes should be permitted.

The discharge of wastes from coasts into the marine environment is likely to increase in the future. There are few areas of the world in which waste treatment has been able to keep pace with economic and population growth. Moreover, in many areas industrial expansion and population are both becoming more concentrated in coastal areas. One third of the population of the United States already lives in the 15 per cent of the United States land area which is considered coastal, and this coastal concentration of population is increasing. The volume of industrial wastes in the United States—already twice the volume

of domestic wastes—is expected to increase sevenfold within a decade. Increasing power demands during the next several decades will be met in part by an increase in the number of nuclear-powered generating plants. Although the impact of increased power generation will be felt most strongly in inland waterways, marine areas will also be affected. In 1969, nine nuclear-powered generating plants were scheduled to be built on Long Island Sound by 1975, with water from the Sound used for cooling. Increased concern about environmental problems will not necessarily act to decrease marine pollution from wastes. Concern about the effects of wastes on inland waters and land is increasing the pressure for marine disposal.

The effects of increasing marine disposal of wastes will be determined by the care taken in the management and conservation of the capacity of the oceans to absorb and recycle wastes. This capacity is, indeed, an important natural resource. Like other natural resources, it can be squandered. In many cases, no more thought is being given to the increased discharge of wastes into the marine environment than has been given to the discharge of wastes into inland waters. The Baltic, many times the size of Lake Erie, may be even more contaminated than Lake Erie. As mentioned above, one of the major problems in the Baltic is de-oxygenation of the water due to an excess of phosphate nutrients. Meanwhile, some parts of the marine environment, particularly mid-ocean areas, are poor in nutrient and as a result are unable to sustain large populations of marine life. Wise disposal of nutritious wastes in these areas might contribute to an expansion of the world's fish resources. Even if such intentional fertilization of mid-ocean areas is not possible, disposal of wastes farther from shore may be preferable because of the importance of coastal, and particularly estuarine, waters to marine life and to man. Heated water from nuclear-powered generating plants can be harmful to some marine life, but it can also be beneficial to the growth of shellfish. There will, however, be little opportunity to reap this benefit if shellfish-producing areas continue to be destroyed by other kinds of pollution. Marine pollution from wastes is not simply a problem of good against evil. A major part of the problem may be how to turn evil into good.

The direct effects of wastes discharged from coasts are usually felt most immediately by the coastal States from which they are discharged, and coastal States possess the authority to deal with this type of marine pollution. Unfortunately, pollution problems arising from wastes have come to be viewed by some as luxury problems on which only the developed countries can afford to spend time and money. In the case of wastes discharged from coasts, this point of view overlooks the importance of coastal waters as a natural resource to both developing and developed countries. It is unrealistic to expect that many Governments will protect coastal areas from pollution by wastes when these areas are of little or no economic importance, but it is a mistake to assume that coastal areas are in fact of little or no economic importance. With many developing countries depending increasingly on fish for food, off-shore wells for oil and foreign exchange, and beaches for tourism—to mention but a few of the important uses of coastal areas in developing countries—the control of pollution from

coastal waste disposal can clearly be viewed in many cases in the context of the development of marine resources. Moreover, coastal waste discharges are one aspect of the total waste disposal problem whose impact on freshwater areas has long been recognized as a development problem. The international apparatus which exists to promote development has taken some action along these lines. The United Nations Development Programme has, in co-operation with the World Health Organization, a number of field projects on waste disposal in coastal areas of developing countries. The World Health Organization, in co-operation with the Food and Agriculture Organization, offered its first course on coastal pollution control in 1970. Further financial aid and technical assistance in planning and executing both coastal development and coastal pollution control will contribute to both the economic development of marine resources and the solution of waste disposal problems of developing countries.

The wide variety of effects which wastes can cause in the marine environment, as well as the many sources and types of waste, makes the control of pollution from wastes a particularly complex task. In many countries, control of wastes in the marine environment depends on co-operation among authorities whose primary missions are diverse (public health, wild-life conservation, fisheries, agriculture) as well as co-operation between local and national authorities. The needed co-operation is often lacking. During the summer of 1970, a Genovese city official who had closed the city's beaches because of pollution from wastes was overruled by a national official who asserted that the coast was so badly polluted that only national authorities had the power to act. This incident is admittedly an unusual manifestation of the problems arising from divided authority—it is surely more often the case that divided authority leads to lack of any action—but it illustrates the frustrations which many officials have experienced. On the international level, authority is not so much divided as non-existent. Officials from France and Italy have traded charges over pollution in the Mediterranean. The French claim they are the victims of wastes from Italy; the Italians claim they suffer pollution from oil slicks originating in the port of Marseilles. Handling such problems through the normal diplomatic channels may well be slow and difficult. Direct co-operation on such problems between non-diplomatic officials in different countries may be desirable. Indeed, the reluctance of local officials in some countries to surrender authority to either national officials or international organizations may make such co-operation a necessity.

A basis for the international regulation of waste disposal can be found in article 25 of the Geneva Convention on the High Seas (which has been quoted above in the discussion of oil) on the premise that the wastes disposed of may be "harmful agents" if they are high in toxicity or if for other reasons they cause substantially deleterious effects. The obligation placed upon the parties by that article to co-operate with competent international organizations in taking measures for the prevention of pollution by such harmful agents requires as a condition precedent that an international organization adopt recommendations or regulations for measures. This has been done to a limited extent for radioactive wastes by the International Atomic Energy Agency (IAEA) and for toxic

chemicals by the World Health Organization. On a more general basis, studies have been undertaken by regional groups and by the Joint Group of Experts on the Scientific Aspects of Marine Pollution. The increasing concern with the effects of some wastes on food resources and human health is likely to lead to the adoption of standards at least for some substances and to recommendations on means of disposal.

It is also of course open to individual States to bring an international claim on the basis of general international law if it could show that it has suffered injury within its own territorial sea or if it were damaged in respect of fish stocks which were normally exploited by nationals of that State. Presumably the doctrines of Corfu Channel and Trail Smelter would be relevant but of course there would be serious questions regarding the degree of the harm and the standards of proof required. However, it is quite obvious that this is a problem that does not lend itself to adequate treatment through international claims and that what is needed is action by an international organization which will bring into play the existing obligation of article 25.

**Wastes Dumped from Vessels**

Wastes dumped from vessels are discussed separately here because some of them pose problems which are qualitatively different from the problems which arise from wastes which are discharged from coasts. Two methods of dumping wastes from vessels should be distinguished: wastes which are dispersed and wastes which are containerized. Wastes dispersed from vessels differ from wastes discharged from coasts primarily in that they are more likely to be discharged directly into international waters. Containerized wastes dumped from vessels, in addition to being dumped frequently in international waters, are often highly toxic materials.

According to an IMCO survey, the dispersed wastes include dredging spoils, industrial wastes, garbage and trash, large pieces of machinery and sewage sludge. The United States disposed of about 48 million tons of wastes in this way during 1968. New York City has been dumping sewage sludge in international waters for 22 years, thus creating a "dead sea" at the mouth of its harbour. Researchers who recovered a fish from almost five miles deep in the Puerto Rico trench also recovered "empty paint cans, fruit juice cans, beer can lids, pieces of old aluminum, empty bottles and flashlight batteries" from the same depth. The effects of the dispersed wastes are as varied as the effects of wastes discharged from coasts. Some are clearly harmful, poisoning marine life and tearing fishing nets. Others may provide habitats for marine life. The feasibility of creating artificial reefs out of discarded automobiles and automobile tires is being studied.

Wastes are often containerized in the hope that they will remain containerized for long periods, with dilution occurring very slowly or not at all. The wastes which are containerized and dumped in the oceans are usually wastes whose dispersion is considered dangerous. These include low-level radioactive wastes and highly toxic chemicals. Many of these chemicals—such as the chem-

ical weapons mustard gas and nerve gas—are wastes only in the sense that someone wants to be rid of them, and not in the sense that they are the unwanted by-products of human activities. Disposal of containerized wastes in the marine environment inside or outside national jurisdictions is often Government-supervised or a Government activity.

How much containerized waste has been dumped in the oceans is not known. Registration of dumpings has been recommended and studied several times in the past, but Governments have been reluctant to reveal what they dump and where they dump it. What is known about the dumping is that it has been going on for some time and continues today. Surprisingly high levels of arsenic in the Baltic Sea led recently to the discovery that 7,000 tons of arsenic had been dumped almost 40 years ago in concrete containers, reportedly enough to kill the population of the world three times over if properly administered. In recent years, nerve gas has been dumped in the Gulf of Mexico and the Atlantic Ocean by the United States and a number of European countries continue to dump containerized chemical weapons and radioactive wastes in the Atlantic and Mediterranean. In some cases, extensive studies have been undertaken to determine the likelihood of damage. In other cases, it is difficult to know how much care has been taken because the operations were conducted under military secrecy.

The extent of damage from containerized wastes so far appears to be minor. There is no evidence that there has been damage from containerized radioactive wastes, although in at least one instance a container of low-level radioactive wastes dumped in the oceans has been found washed up on shore. Containerized chemical wastes have caused damage in several cases. Danish fishermen operating off the Swedish coast in the Baltic have been burned by fish contaminated with German mustard gas dumped by the Allies after the Second World War. Similar incidents have occurred elsewhere. Recent research indicates that fish and plant life on and near the ocean floor is more extensive than was once thought, and any estimate of the potential danger from containerized wastes may have to be increased accordingly. Moreover, ocean currents are still not well understood, particularly at great depths. Prediction of where a container of wastes dumped in the oceans will lie, even immediately after it is dumped, is very difficult.

Perhaps the greatest potential danger from containerized wastes arises from the uncertainty of when and how the material in the container will be dispersed in the marine environment. Containers are usually made of very strong materials, often concrete or steel or both. Concrete, however, does crumble and steel rusts. Earthquakes on the ocean floor can break open any containers known. No one expects the containers to last forever, even those who make them. The usual expectation appears to be that materials will escape from the containers slowly and be diluted in vast quantities of sea water. No one can guarantee that this will indeed happen, and even if it does, that marine life will not be contaminated.

Since little is known about the quantities of containerized wastes dumped in the oceans in the past, it is impossible to estimate whether dumpings are

likely to increase or decrease. The United States has curtailed dumping containerized radioactive wastes in the oceans, but a number of European countries and perhaps others as well continue to dump considerable quantities of low-level radioactive wastes. With the uses of atomic power and radioactive materials expected to increase rapidly in many countries during the next few decades, and with suitable areas for burial of radioactive wastes on land scarce in many countries, there will be no scarcity of radioactive wastes to dump in the oceans. Containerized chemicals to be dumped in the oceans are also plentiful; marine disposal of outmoded or defective chemical weapons will probably continue.

The inadequacy of the international machinery to deal with marine dumping of containerized wastes has been most clearly demonstrated by the sinking of a ship loaded with nerve gas rockets in the Atlantic Ocean by the United States in August 1970. American citizens, including Florida State officials, were able to file a suit in an American court and at least force what had been planned as a secret military operation into the public arena. It was possible that this suit would stop the proposed dumping. The international machinery was not nearly as fast-moving or effective. The Bahamas, whose citizens probably had at least as much at stake as those of the State of Florida, could only act through normal diplomatic channels. No mechanism was available for the public presentation of technical testimony concerning the nerve gas dumping by interested parties outside the United States or for an independent evaluation of the dumping on the international level. It may be that the dumping will not cause any damage and it may be the case the marine disposal was the best of the available alternatives. Necessity in this one case does not, however, justify the general lack of mechanisms for reconciling international disagreements and protecting the common interest. The dumping of the nerve gas in international waters was no more a private matter of the United States than it was a private matter of the United States Army.

The problem of wastes dumped from vessels, like the problem of chlorinated hydrocarbons, is clearly a problem of widespread concern. Improved machinery for bringing the best available scientific and legal expertise to bear on this problem is needed. Damages from these wastes have in the past been few, but the dangers are so great that constant surveillance, and perhaps strict liability as well, is called for. Surveillance cannot take the form of monitoring by an international agency or by individual States simply because the practice of dumping wastes in a big ocean is so difficult to detect. Registration of dumpings of dangerous materials would appear to be the most appropriate first step in surveillance. Registration need not be a mere report of how much of what was dumped where, but might well include a detailed account of safety procedures. Once registration is established, the appropriate international, intergovernmental and scientific organizations might consider setting standards for marine dumping of wastes. The activities of the Committee on Space Research (COSPAR) of the International Council of Scientific Unions in setting standards for the biological decontamination of space equipment is an indication that standard-setting can be based firmly on scientific expertise rather than political expediency. It is important to recognize, however, that COSPAR sets standards for scientific activi-

ties only. In the case of marine dumping, health and security interests may also be at stake and standard-setting cannot be left solely to marine scientists.

It is only in respect of radioactive waste that there has been international activity on dumping. The explicit reference to the radioactive waste in article 25 of the High Seas Convention and the resolutions of the 1958 Conference on the Law of the Sea have brought about a series of recommendations by the IAEA for monitoring and reporting. However, no regulatory action has been taken by the IAEA beyond such procedural recommendations. The European Nuclear Energy Agency has supervised a dumping of containerized radioactive wastes. With regard to dumping of other wastes, whether containerized or not, there appear to have been no measures taken by international organizations up to the present time. As we have observed above, such action by international organizations could bring into play the obligations placed on States by article 25 to exercise measures of control. Recent incidents have shown that toxic chemical wastes are unquestionably "harmful agents" which could have serious deleterious effects for human life.

Marine dumping of dispersed and containerized wastes would be subject to controls under the draft United Nations Convention on the International Sea-Bed Area, submitted by the United States for discussion to the United Nations Committee on the Peaceful Uses of the Sea-Bed and the Ocean Floor beyond the Limits of National Jurisdiction. The relevant article would obligate States to conduct all their activities in the International Sea-Bed Area, which "comprises all areas of the sea-bed and subsoil of the high seas seaward of the 200 metre isobath adjacent to the coast of continents and islands", "with strict and adequate safeguards for the protection of human life and safety and of the marine environment". Thus, according to the Legal Advisor of the State Department, a State Party to the Convention could be brought before the Tribunal, an organ of the Authority to be set up by the Convention, "on account of either a potential or actual deposit on the sea-bed of a material or substance which might harm the marine environment". The marine environment would extend beyond the sea-bed area and include the waters above from coast to coast. It is presumed that this obligation would extend to dumping, whether dispersed or containerized, if such dumping involved a potential or actual deposit on the sea-bed. Thus, as the Representative of the United States observed in the United Nations Sea-Bed Committee, "if the draft Convention were today in force any contracting party would have been able to bring the United States before the Tribunal in respect of its proposed dumping of nerve gas in the ocean" and the United States would be required to abide by the decision of the Tribunal. The obligations, combined with extensive provisions for compulsory settlement of disputes and considerable enforcement authority, would be a considerable step beyond the present situation under article 25 of the Convention on the High Seas. However, this draft is still in its early stages and there can be no telling when, or if, it will be more. There would seem to be reason to continue other efforts towards the regulation of marine dumping, particularly of dangerous containerized wastes, while at the same time pressing for a treaty with more effective provisions for the protection of the marine environment from pollution.

Action in the area of marine dumping need not, however, come only through the initiative of international organizations and Governments. In a number of countries, action on pollution problems of the "dangerous practices" type has been stimulated largely through the initiatives of private citizens and concerned organizations who have taken pollution problems to court. The effectiveness of such private actions varies with the situation, but they must be considered an important mode of action where Governments who are responsible for controlling pollution are participants in practices which may cause pollution. An international mechanism for handling complaints and grievances from private groups as well as Governments might contribute to the control not only of marine dumping of wastes but to the control of other dangerous practices as well. Moreover, such a mechanism might be one form in which problems of international concern could be adequately discussed from both the technical and legal points of view.

**Some Concluding Observations**

Marine pollution is, of course, but a part of the totality of environmental problems which confront us today. The immediate effects of marine pollution are not as severe as are the immediate effects of pollution of air and inland waters in many countries, though the potential for catastrophe may be greater due to the global character of marine environment and the fact that it is the ultimate receptacle for so many pollutants. It is not, however, either possible or desirable to limit problem-solving efforts to one or even a small number of problems. Marine pollution problems have their place in the total environmental problem and must be dealt with. Nor is it either possible or desirable to view environmental problems solely from a single point of view, and each of the problems discussed here as a marine pollution problem may well be found discussed elsewhere in a different context. Wastes discharged from coasts are not only a marine pollution problem; they are also a part of the problem of the proper use of the coastal and fluvial margin, a problem which includes land-use planning, urban population growth, the building of dams and the digging of canals. DDT is not only a marine pollution problem; it should also be viewed as an agricultural problem and as a health problem. What we call marine pollution problems here are, in reality, part of a vast overlapping set of problems which will have to be cut up again and again in different ways before the solutions become clear.

The comprehensiveness which is essential to reaching such solutions will be gained only through new efforts to reveal the full complexity inherent in the problems themselves. A purely piece-meal approach, characterized by approaching a single problem without considering its relationship to others would not be adequate. The attempt to achieve comprehensiveness in a single leap may be equally illusory. Even if a global environmental authority could be set up tomorrow, the difficulties and obstacles will have to be dealt with through a variety of specialized instrumentalities. This has come to be recognized on the international level by the specialized agencies and the United Nations bodies

concerned. The decision to hold a United Nations Conference on the Human Environment in 1972 has had a role in clarifying the various tasks of specialized agencies and has stimulated as well new activities by international non-governmental organizations. Along with these activities there has come to be a greater recognition of the need for regional pollution control organs since it is apparent that although pollution is a global problem, it is not uniformly global. Regional arrangements in the Baltic, the North Sea, Mediterranean, Caribbean and perhaps in the Arctic are now under way, and it is likely that these organs will have a decisive part to play in achieving day-to-day practical controls. The adoption of standards and procedures, by international global and regional organizations, even though only recommendatory, can have an added degree of effectiveness by virtue of the open-ended obligation of article 25 of the Convention on the High Seas on States Parties to take anti-pollution measures in co-operation with competent international organizations. On that basis, supervisory and surveillance machinery may be more easily instituted by international organizations pending the conclusion of new treaties.

In short, we need a many-sided institutional approach to achieve the right balance. Pollution problems will not be solved by a single discipline, a single institution or a single wave of enthusiasm. Science can provide certain types of information, but that information will have to be communicated effectively to the international and national decision-makers. There is certainly a need for new institutions, though a large part of the solution will lie also in making old institutions more effective. There is as well a continuing need for maintaining the needed pressure from scientists, professional groups and the public at large. The fact that pollution has come to be seen as a problem of great intricacy in a world where many cannot afford to be clean underlines the importance of sustained professional concentration on the whole range of problems.

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